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## AVIFAUNA OF HAMMOCKS AND SWAMPS ON JOHN F. KENNEDY SPACE CENTER


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**Abstract.**—Birds were surveyed in oak-cabbage palm hammocks, red bay, live oak and laurel oak hammocks, hardwood swamps, and willow swamps on John F. Kennedy Space Center using the variable distance circular plot method to determine the importance of such habitats for use in environmental impact assessment. The Carolina Wren (*Thryothorus ludovicianus*) and Northern Cardinal (*Cardinalis cardinalis*) were the two most abundant breeders in all woodland types. Breeders characteristic of interior central Florida were rare and did not nest in the study areas. Broad-leaved woodlands are important for the maintenance of regional avian diversity for much of coastal Florida, because several breeders, such as Red-shouldered Hawks (*Buteo lineatus*) and Barred Owls (*Strix varia*), nest primarily within these woodlands. These species have large territory sizes and occur in low densities, characteristics which must be considered in regional land-use planning if minimum population sizes are to be maintained.


Few studies have been conducted on land bird community composition as it relates to different vegetation types in Florida (Rowher and Woolfenden 1969, Robertson and Kushlan 1974, Hirth and Marion 1979). Bird composition in broad-leaved woodlands in peninsular Florida was investigated by Robertson (1955), Woolfenden (1967; 1968a, b), Rowher and Woolfenden (1969), Kale and Webber (1968a, b; 1969a, b), and Cutright (1981). These studies have shown a breeding avifauna characteristic of woodlands impoverished in both species richness and density when compared to woodlands north of Florida.

The number of breeding bird species in woodlands declines southward along the peninsula. Also, many species nest farther south in the interior rather than along the coasts (Robertson 1955, Rowher and Woolfenden 1969, Robertson and Kushlan 1974, Emlen 1978). These distribution trends may occur because tropical species are deterred from northern movements by physiographic barriers and continental species may be poorly adapted to conditions of the peninsula (Robertson 1955, Rowher

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and Woolfenden 1969). These trends indicate that the determination of bird composition in woodlands for specific areas may require site-specific surveys.

Several different types of woodlands have been mapped on John F. Kennedy Space Center (KSC) for land-use planning and long-term environmental monitoring purposes (Provancha et al. 1986a). A one-year survey was conducted to determine seasonal bird assemblages at a possible construction site having four woodland types on KSC. This survey was followed by another one-year survey to determine seasonal bird assemblages for the same four woodland types adjacent to other operational areas on KSC. The objective of this paper is to characterize avian composition within these woodlands and compare the avian composition to composition expected (Breininger, unpublished KSC wildlife habitat association model) from range maps and studies conducted elsewhere in Florida.

## Study Area and Methods

Marshes, scrub, flatwoods, hammocks, and swamps dominate much of the landscape at KSC (Sweet et al. 1979, Stout 1980). The KSC consists of 57,000 ha of land and lagoonal waters and is located on the northern part of Merritt Island on the east coast of central Florida. Areas of KSC not being used by the space program are managed as Merritt Island National Wildlife Refuge. Several subtropical and temperate faunal and floral assemblages occur together on KSC (Provancha et al. 1986b). This area has been mapped as a transition zone between a temperate broad-leaved evergreen forest and tropical forest (Greller 1980). Cypress swamps do not occur on KSC, and mangrove swamps have been greatly impacted by recent freezes (Provancha et al. 1986b).

Two types of hammocks and two types of freshwater swamps were surveyed to describe avian composition. All four of these cover types are common and are the predominant broad-leaved woodlands on KSC (Provancha et al. 1986a). Oak-cabbage palm hammock (OCP) has a canopy typically dominated by live oak (*Quercus virginiana*), but cabbage palm (*Sabal palmetto*), laurel oak (*Quercus laurifolia*), elm (*Ulmus americana*), and red mulberry (*Morus rubra*) also occur. Shrubs of tropical affinity typically dominate the understory (Schmalzer and Hinkle, unpublished report). Red bay-live oak-laurel oak hammock (RBL) has a canopy dominated by live or laurel oak, but redbay (*Persea borbonia*) often occurs. The understory is typically dominated by saw palmetto (*Serenoa repens*). Hardwood swamps are typically dominated by deciduous species, especially red maple (*Acer rubrum*), although elm and persimmin (*Diospyros virginiana*) may be common. These swamps often include evergreen taxa such as laurel oak and cabbage palm. Ferns are often abundant in the understory (Schmalzer and Hinkle, unpublished report). Willow swamps are dominated by small deciduous Carolina willow (*Salix caroliniana*) trees. However, red maple and wax myrtle (*Myrica cerifera*) are often present. The understory is often dominated by aquatic plants such as arrowhead (*Sagittaria stagnorum*). This cover type occurs in deeper water and on sites with longer hydroperiods than hardwood swamps (Schmalzer and Hinkle, unpublished report).

The variable circular plot (VCP) method (Reynolds et al. 1980) was used to sample avifauna in two separate surveys. The method was selected for its advantages in patchy habitat, large geographic areas, rugged terrain, and to allow sampling across a large variation of habitat conditions. It also was selected for its perceived advantages in long-term

monitoring of a large number of sites having several patches of different vegetation types. This study could then be used as a pilot study for development of a long-term environmental monitoring tool. The first survey was conducted from June 1983 to May 1984; the second survey was conducted from March 1985 to February 1986. Stations for the first survey were centrally located on KSC and each was sampled 22 times, about every 22 days. Stations for the second survey were located throughout KSC south of Route 402 and each station was sampled eight times, about every 46 days. These surveys excluded the northern one-third of KSC.

Both surveys involved sampling routes consisting of stations in many different cover types. Routes were comprised of eight stations arranged in a roughly elliptical pattern about 200 m apart. Six routes were used in the first survey and 15 in the second. Both studies used routes that included stations located within vegetation types other than woodlands.

Counts were made for seven minutes at each station; pause time was not used after arriving at a station since birds detected upon arrival were not always detected again (Anderson and Ohmart 1981). All birds seen or heard were recorded except those flying over the area without landing. Distances were usually estimated, although a rangefinder was used periodically to keep the investigator calibrated. One month was used to practice the technique prior to the first survey. Surveys were conducted between one-half hour before sunrise to three hours after sunrise. No surveys were conducted during rain or windy conditions. Data from both surveys were grouped into the four cover types for the determination of the effective detection distance (x). The x-value was determined for each species in each cover type by estimating the inflection point of a graph of the number of birds in concentric 10 m bands, according to the criteria of Reynolds et al. (1980).

Estimates of birds/ha were calculated by summing the number of detections within x, dividing by the number of visits and $\pi x^2$, and multiplying by 10,000. Estimates of density were calculated for all species where the number of detections for both surveys combined was $\geq 40$ (Burnham et al. 1981) within a cover type. Estimates were calculated for arbitrary seasons which were spring (Mar, Apr, May), summer (Jun, Jul, Aug), fall (Sep, Oct, Nov), and winter (Dec, Jan, Feb) separately for both studies. The mean number of birds/visit was calculated for every species in each cover type by summing the total number of detections for both studies and dividing by the number of visits.

Two-way and three-way factorial analysis of variance (ANOVA) models were used to test whether each species differed by year, season, or habitat. An alpha level of 0.05 was used for tests of significance. Differences discussed below are based on ANOVA. In no cases were interaction terms significant.

## RESULTS

The Carolina Wren (*Thryothorus ludovicianus*) and Northern Cardinal (*Cardinalis cardinalis*) were the most frequently occurring (Table 1) and most abundant (Table 2) breeding birds, representing the only species sighted enough to allow the estimation of density in all four cover types. Both were significantly ($P<0.05$) more abundant in the first study year (1983-1984) than in the second (1985-1986). Carolina Wren densities were significantly higher in spring than in fall and winter; densities were significantly higher in summer than in winter, but not fall. Northern Cardinal densities were significantly higher in spring and summer than in fall and winter. Densities between spring and summer or fall and winter were not significantly different for either species.

**Table 1. Mean birds/visit in hammocks and swamps on John F. Kennedy Space Center, Florida, 1983-1986.[1,2]**

| Species | Hammocks | | Swamps | |
|---|---|---|---|---|
| | Live oak, cabbage palm (N = 178) | Redbay, laurel & live oak (N = 160) | Mixed hardwood (N = 136) | Willow (N = 68) |
| Breeding residents | | | | |
| Carolina Wren | 0.98 | 0.76 | 0.62 | 0.66 |
| Northern Cardinal | 0.54 | 0.58 | 0.47 | 0.54 |
| White-eyed Vireo | <0.03 | 0.35 | 0.18 | 0.19 |
| Blue Jay | 0.06 | 0.14 | 0.09 | 0.20 |
| Red-bellied Woodpecker | 0.12 | 0.04 | 0.04 | 0.12 |
| Pileated Woodpecker | 0.10 | 0.01 | 0.03 | |
| White Ibis[4] | 0.01 | | 0.09 | 0.29 |
| Common Grackle[3] | 0.04 | 0.09 | 0.05 | 0.09 |
| Yellow-billed Cuckoo | 0.02 | 0.01 | 0.05 | 0.06 |
| Red-shouldered Hawk | 0.07 | 0.04 | 0.05 | <0.01 |
| Black Vulture | <0.01 | 0.02 | 0.07 | |
| Rufous-sided Towhee | | 0.06 | 0.01 | |
| Winter visitors | | | | |
| Yellow-rumped Warbler | 0.17 | 0.40 | 0.57 | 0.68 |
| American Robin | 0.22 | 0.19 | 0.41 | 0.38 |
| Gray Catbird | 0.04 | 0.29 | 0.13 | 0.22 |
| Common Yellowthroat[5] | <0.01 | 0.02 | 0.05 | 0.10 |
| Ruby-crowned Kinglet | 0.01 | 0.09 | 0.03 | |

[1]Includes all species with > 0.05 birds sighted/visit.
[2]N = total number of visits.
[3]Probably do not nest in these habitats.
[4]Sometimes nest in swamps but did not nest in the swamps surveyed in this study.
[5]All or nearly all individuals were nonbreeders.

White-eyed Vireos (*Vireo griseus*) were of sufficient abundance only in RBL hammocks to allow density estimates (Table 1). Densities also were significantly higher the first year (1983-1984) than the second (1985-1986), but seasonal densities were not significantly different. No other breeding birds were abundant enough to allow density estimation.

Some breeding birds (e.g., Blue Jays *Cyanocitta cristata* and Red-bellied Woodpeckers *Melanerpes carolinus*) were often seen in all four types, whereas, others (Pileated Woodpeckers *Dryocopus pileatus*) appeared to be more restricted to particular cover types (Table 1). White Ibises (*Eudocimus albus*), which nested elsewhere on KSC, occasionally used hardwood and willow swamps for feeding and roosting and OCP hammocks for roosting. Red-shouldered Hawks (*Buteo lineatus*) were observed nesting in OCP hammocks and hardwood swamps where there were large trees, but appeared to use all four woodlands during hunting

activities. Yellow-billed Cuckoos (*Coccyzus americanus*) were most frequently seen in swamps. Black Vultures (*Coragyps atratus*) were sighted in all but willow swamps and have been observed nesting in RBL hammocks. The Green-backed Heron (*Butorides striatus*), Barred Owl (*Strix varia*), and Northern Flicker (*Colaptes auratus*) were the only additional resident breeders observed nesting in or along the edges of woodlands. The Cooper's Hawk (*Accipiter cooperii*) was rarely sighted in both surveys. Rufous-sided Towhees (*Pipilo erythrophthalmus*) frequented the edges of woodlands, especially in RBL hammocks, but nested in the adjacent scrub habitats.

The Yellow-rumped Warbler (*Dendroica coronata*) was the most abundant winter resident in all but OCP hammocks, where it did not occur often enough to allow density estimation (Table 2). Densities were not significantly different among the other three cover types or between years. Densities were significantly higher in winter than in fall and spring. Densities between fall and spring were not significantly different. No significant differences occurred between habitat types for the Gray Catbird (*Dumetella carolinensis*) although densities were significantly higher in the first year than the second. No significant differences occurred among the other three seasons. The American Robin (*Turdus migratorius*) was sighted in the four types, but only abundantly enough in OCP hammocks and hardwood swamps to allow density estimations (Table 2); densities between the two types were not significantly different. Densities were significantly different between years. The Common Yellowthroat (*Geothlypis trichas*) was most common in willow and hardwood swamps (Table 1). Nearly half of the stations in hardwood swamps lacked an understory and these were devoid of Common Yellowthroats. Ruby-crowned Kinglets (*Regulus calendula*) were occasionally sighted along edges, particularly in RBL hammocks.

## DISCUSSION

The Carolina Wren, Northern Cardinal, White-eyed Vireo, Yellow-rumped Warbler, and Gray Catbird were the only species abundant enough to allow density estimation. They occupy a broad variety of habitat conditions (Hamel et al. 1982). This, combined with their high seasonal and yearly variation, suggests that it would be difficult to use their VCP densities as indicators of environmental change. Seasonal differences in density that occurred were probably affected more by differences in observability rather than differences in actual density for the permanent residents. Seasonal changes in observability have been described for many species (Best 1981, Ekman 1981). Reasons for yearly differences are unknown; they may include actual differences in sites where the surveys occurred or yearly variations in population sizes due to disease, food availability, or weather. The sites studied during the

**Table 2. Density estimates (birds/ha) of birds in hammocks and swamps on John F. Kennedy Space Center, Florida, 1983-1986.[1]**

| | Hammocks | | | | Swamps | | | |
|---|---|---|---|---|---|---|---|---|
| | Live oak, cabbage palm | | Redbay, live & laurel oak | | Mixed hardwood | | Willow | |
| | 1983-1984 (N = 3) | 1985-1986 (N = 14) | 1983-1984 (N = 4) | 1985-1986 (N = 9) | 1983-1984 (N = 4) | 1985-1986 (N = 6) | 1983-1984 (N = 2) | 1985-1986 (N = 3) |
| Spring | | | | | | | | |
| Carolina Wren | 2.6 | 1.6 | 2.8 | 1.8 | 1.6 | 1.3 | 5.2 | 2.6 |
| Northern Cardinal | 1.7 | 1.0 | 1.6 | 1.3 | 1.3 | 1.2 | 2.2 | 2.6 |
| White-eyed Vireo | 0.0 | 0.0 | 2.5 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yellow-rumped Warbler | 0.0 | 0.0 | 3.4 | 1.8 | 0.8 | 0.0 | 0.0 | 1.3 |
| Gray Catbird | 0.0 | 1.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Totals | 4.3 | 3.6 | 10.6 | 5.5 | 3.7 | 2.5 | 7.4 | 6.5 |
| Summer | | | | | | | | |
| Carolina Wren | 3.0 | 1.1 | 1.1 | 0.9 | 2.2 | 1.3 | 1.5 | 2.0 |
| Northern Cardinal | 2.1 | 0.2 | 0.9 | 1.2 | 1.4 | 0.8 | 1.4 | 0.0 |
| White-eyed Vireo | 0.0 | 0.0 | 1.4 | 0.5 | 0.0 | 0.0 | | |
| Totals | 5.1 | 1.3 | 3.4 | 3.6 | 3.6 | 2.1 | 2.9 | 2.0 |
| Fall | | | | | | | | |
| Carolina Wren | 3.6 | 0.7 | 1.1 | 0.9 | 0.9 | 0.7 | 1.0 | 1.2 |
| Northern Cardinal | 1.2 | 0.3 | 0.8 | 0.8 | 0.5 | 0.4 | 0.6 | 0.8 |
| White-eyed Vireo | 0.0 | 0.0 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yellow-rumped Warbler | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.6 | 8.0 |
| Gray Catbird | 0.0 | 0.0 | 0.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Totals | 4.8 | 1.0 | 4.3 | 2.3 | 1.4 | 1.1 | 11.2 | 10.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Winter | | | | | | | | |
| Carolina Wren | 0.8 | 1.1 | 2.8 | 0.7 | 0.6 | 0.2 | 0.0 | 0.6 |
| Northern Cardinal | 0.8 | 0.8 | 0.6 | 0.3 | 0.3 | 0.8 | 0.2 | 0.0 |
| White-eyed Vireo | 0.0 | 0.0 | 1.3 | 0.4 | 0.0 | 0.0 | 0.0 | 0.5 |
| Yellow-rumped Warbler | 0.0 | 0.0 | 15.5 | 0.0 | 14.6 | 16.1 | 3.5 | 6.8 |
| Gray Catbird | 0.0 | 0.0 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| American Robin | 1.0 | 1.2 | 0.0 | 0.0 | 2.4 | 2.1 | 0.0 | 0.0 |
| Totals | 2.6 | 3.1 | 21.8 | 1.6 | 17.9 | 19.2 | 3.7 | 7.9 |

[1]N refers to the number of stations.

first study had a dense understory and subcanopy, but many stations during the second study had little understory and subcanopy. No data were collected to measure these differences. Population fluctuations have been described for many species (Holmes et al. 1986). Caution must be exercised when interpreting data from different years and seasons (Anderson et al. 1981), particularly with the accuracy of the results when total mapping procedures of color-banded birds are not used as a method to determine absolute density (Verner 1985).

There were many additional species observed in woodlands on KSC. They were not detected abundantly enough to allow density estimation, suggesting that the utility of the VCP method is limited in these habitats. Although breeding bird population densities for Florida broad-leaved forests and forest edge are markedly lower than for the adjacent southeastern coastal plain, this is apparently not true for pine flatwoods (Robertson and Kushlan 1974) and some scrub habitats (Breininger and Schmalzer 1990). The mean number of birds sighted per visit in hammocks and swamps was always several times lower than the mean number of birds sighted per visit in scrub for all seasons and across all habitat types, except for recently burned scrub. The utility of the VCP method may therefore vary by habitat type.

Species such as the Northern Parula (*Parula americana*), Blue-gray Gnatcatcher (*Polioptila caerulea*), and Red-eyed Vireo (*Vireo olivaceus*) that are abundant breeders in interior woodlands (Woolfenden 1967) but not coastal woodlands in central Florida (Kale and Webber 1968a, b, 1969a, b; Rowher and Woolfenden 1969) were not sighted in this study during the nesting season. The KSC is within the suggested breeding range of many other species (Robertson 1955, Hamel et al. 1982) that were not observed nesting in woodlands on KSC in this study. Differences in avifauna may occur between the east and west Florida coastline. Yellow-billed Cuckoos were common on the west coast (Rowher and Woolfenden 1969) but were not common in this study or in another woodland on the east coast (Kale and Webber 1968a, b; 1969a, b).

Most of the breeding birds found within these woodlands on KSC also are found in adjacent habitats, often in similar or higher densities (Breininger and Schmalzer 1990). Bald Eagles (*Haliaeetus leucocephalus*), Great Crested Flycatchers (*Myiarchus crinitus*), and Downy Woodpeckers (*Picoides pubescens*) can use hammocks or swamps for nesting, but they use mostly pinelands. Most wading birds nest in mangroves or on spoil islands and feed much more abundantly in other habitats (Breininger and Smith, unpublished data).

Broad-leaved woodlands are important for the maintenance of regional populations of Red-shouldered Hawks, Cooper's Hawks, Barred Owls, Pileated Woodpeckers and possibly Black Vultures and Turkey Vultures (*Cathartes aura*). These species occupy large feeding territories

(Schoener 1969), occurring in low densities and occupying higher trophic levels. This study and other unpublished data confirm observations by Cruickshank (1980) who suggested that Barred Owls and Red-shouldered Hawks are characteristic of hammocks and swamps, whereas, Great Horned Owls and Red-tailed Hawks are characteristic of pinelands in Brevard County. The Cooper's Hawk was seen and heard giving nest defense calls (Bent 1937) almost on a daily basis in the late winter and spring of 1988 and 1989 in several woodlands on KSC (D. Breininger and B. Smith, pers. obs.).

Since many of the neotropical migrants that are area-sensitive breeders (Robbins 1979, 1980; Whitcomb et al. 1981; Hamel et al. 1982) do not breed in much of the Florida peninsula, relationships with woodland size are often associated with minimum territory size requirements (O'Meara 1984). Several species can utilize small islands that are part of a group of islands large enough to meet habitat requirements (Harris and Wallace 1984, O'Meara 1984, Gutzwiller and Anderson 1987, Bushman and Therres 1988). Others such as the Red-shouldered Hawk, Barred Owl and Pileated Woodpecker may require larger tracts (Craighead and Craighead 1956, Hamel et al. 1982).

Bird use was not uniform across the four woodland types in this study or in a north Florida hammock (Noss 1988). Habitat features such as hydrology, tree size, availability of nest cavities, and the cover by deciduous and evergreen canopy all vary among woodland types. Red-shouldered Hawks require large trees for nesting (Bushman and Therres 1988). Barred Owls often prefer areas associated with water, but this may occur due to a need for large trees with cavities, which are often associated with these areas, and not that Barred Owls are attracted to water itself (Devereux and Mosher 1984). Pileated Woodpeckers choose foraging habitats having high densities of logs and snags, dense canopies, and tall shrub cover (Bull and Meslow 1977) and require large snags for nesting (Bull 1981). Most studies regarding breeding habitat for woodland species have been conducted outside Florida where habitat requirements may differ (Gutzwiller and Anderson 1987). There has been little study conducted to quantify habitat requirements of these species in Florida and the availability of these features in Florida woodlands.

Florida woodlands support higher avian density and biomass values during the winter than during the summer breeding season, unlike northern areas (Harris and Vickers 1984). Wintering species abundant in KSC woodlands, such as Yellow-rumped Warblers, Gray Catbirds, and American Robins, are abundant in several other KSC habitats. Common Yellowthroats use woodlands but are much more abundant in other habitats such as scrub (Breininger and Schmalzer 1990). Hermit Thrushers (*Catharus guttatus*), Black-and-white Warblers (*Mniotilta varia*), and Ovenbirds (*Seiurus aurocapillus*), wintering locally in hammocks and

swamps, (Cruichshank 1980) were not abundant. Many transients pass through KSC (Taylor and Kershner 1986), including hammocks and swamps (Cruickshank 1980), during migration. Such transient species can occur in large numbers during short periods but these events can easily be missed, as occurred in this study. Woodland size has been found to effect wintering bird composition in urban woodlands (Tilghman 1987). Cox (1988) suggested that large tracts of maritime hammocks may be important during brief periods when large numbers of migrants pass through the area. Alteration of nonbreeding habitat may have greater impact on populations than alteration of breeding habitat because many migratory species concentrate outside their breeding habitat (Terborgh 1980). Many overwintering species spend more time in Florida than they spend on their northern breeding grounds (Keast 1980).

Results of this study suggest that common bird community survey methods, used on a local scale for determination of conservation value, provide limited information regarding the importance of woodlands for maintaining biological diversity. Maintenance of biodiversity has been identified as a primary issue in natural resource management (Thomas and Salwasser 1989). Future surveys in broad-leaved woodlands on a local scale might best focus on methods that provide information on the abundance and distribution of species that require woodlands in Florida, as well as their habitat requirements and the distribution of the required habitat features.

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